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AN APPARATUS FOR THE PRODUCTION OF FINE METAL POWDERS

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INTRODUCTION

As a preliminary step to an investigation on the slip casting of metal powders, an apparatus has been constructed for the production of atomized nickel. A feature of this apparatus is the production of spherical-shaped powder particles which are desirable for slip casting experiments.

DESCRIPTION OF APPARATUS

The apparatus illustrated in Figure 1 consists of a chamber 3 feet in diameter and 5 feet high constructed of sheet metal. A 12 inch deep pan partly filled with water is placed inside the chamber to quench and collect the powder. Several air vents are located around the top of the chamber which is closed with a 1/2 inch thick transite cover. An induction heating coil is mounted above a 3 inch diameter hole in the center of the cover. Inside the heating coil is a magnesium oxide lined melting crucible the bottom of which extends through the hole, flush with the inside of the transite cover. From a hole in the bottom of the crucible a zirconia-coated quartz tube extends into the atomizing chamber. A cone of sixteen air jets circles the quartz tube with the apex of the cone pointed downward toward the end of the pouring tube. A ceramic shield insulates the tube from the blast of air from the jets. This is shown in Figure 2.

In operation, the hole in the bottom of the crucible is plugged by a zirconia rod extending upwards out of the crucible top. A quantity of nickel is then carefully charged and melted by means of the induction heating coil. When the nickel is molten and at a temperature

of about 1550°C (2820°F) a valve is opened to admit air at 150 psi to the jets. The zirconia plug is then removed allowing the molten metal to flow from the crucible through the quartz tube to be atomized by the air blast from the jets.

DISCUSSION

A magnesium oxide lined crucible was used to prevent slagging with any nickel oxide that may form and the quartz pouring tube was coated with zirconia as a precaution against reaction with the molten nickel. A better selection of material for the pouring tube would have been zirconia or magnesium oxide but neither was available in tube form.

The size of the bore of the quartz pouring tube was the smallest through which the molten nickel would flow without freezing since it was found that the smaller the bore, the finer the metal powder and the finest powder was desired. The freezing of the metal in the pouring tube depended on the bore, on the length and on the insulation of the tube from the stream of air from the jets.

At first, a six inch long pouring tube was necessary because the air jets were in the form of 3 inch tubes arranged in a cone. Difficulty due to the metal freezing necessitated the shortening of these jet tubes to the form illustrated in Figure 2, which permitted shortening of the pouring tube to 3 inches. With this tube length and a 1/4 inch bore, the molten nickel flowed freely at the rate of 30 lb/min.

The position of the end of the pouring tube with respect to the apex of the air stream from the jets was found to be very important.

At one position, for a given inside angle of the jets, there was an aspirating action drawing the molten metal out of the pouring tube. As the pouring tube was raised or lowered from this position the asperating effect was reduced and in some positions a back pressure occurred which would blow the molten metal out of the melting crucible. This back pressure was due in part to the turbulence of the air blast from the jets and in part to the pressure build up in the atomizing chamber.

Figure 2 illustrates by means of vectors the approximate direction and strength of the air pressure at the apex of the stream of air from the jets. When the end of the pouring tube was placed above the plane cc^1 the air pressure from the vectors A and B forced the molten metal back up the pouring tube and out of the melting crucible. To this was added any pressure build up in the atomizing chambers. When the end of the pouring tube was just below the plane cc^1 there was no pressure acting in the direction of A and B and the aspirating action of the other vectors more than overcame any pressure build up in the chamber. When the end of the pouring tube was lowered too far there was no aspirating action and pressure in the chamber again forced the metal back up the pouring tube.

The pressure in the atomizing chamber was kept to a minimum by allowing the air to escape through a space around the bottom of the chamber and also through the air vents at the top of the chamber.

The ceramic shield around the quartz tube shown in Figure 2 not only served as an insulator against the cooling air stream from the jets but it also served the important function of occupying the space

between the air stream and the pouring tube. Without it the air was drawn from this space by the action of the air from the jets. There was then a difference of pressure across the air stream so that air from the chamber forced its way into this space only to be drawn back out again. This created a circulation of air laden with molten metal particles. These particles accumulated on the pouring tube and on the jet openings tending to seal both.

Another feature was that the ceramic shield had a bore about 3/32 inches larger than the outside of the pouring tube. This allowed the air pressure represented by the vectors A and B (Figure 2) to escape between the pouring tube and the ceramic shield. When the ceramic shield was cemented to the melting crucible or to the pouring tube which prevented this pressure from escaping, the molten metal was blown out of the melting crucible.

If the pouring tube was raised too close to the plan cc[1] some of the molten metal particles were blown into the space between the ceramic shield and the pouring tube and tended to block it.

A water quench was necessary because of the lack of an atomizing tower of sufficient height to ensure particle solidification before they struck the pan.

POWDER

For slip casting purposes it is desirable to have a powder spherical in shape consisting of a large percentage of fine sizes. At 80 psi air pressure the powder produced contained only 3% minus 270 mesh. However, when the pressure was increased to 150 psi the particle size of the powder decreased and 33% was minus 270 mesh.

The larger particles were irregular in shape but as the size decreased the more spherical they became. Figure 3 shows the nearly perfect spheres of the minus 325 mesh powder and since a larger percentage of the powder to be used would be of this size the powder was judged to be satisfactory for slip casting.

SUMMARY

In producing atomized powder with the above described apparatus the following factors were established:-

1. The finest powder is obtained by using the smallest bore tube through which the molten metal will flow freely.
2. Increasing the air pressure will decrease the particle size.
3. The end of the pouring tube should be below the place marked by cc[1] (Figure 2) and in a position so there is an aspirating action drawing the metal out of the pouring tube.
4. The ceramic shield should have a bore larger than the outside diameter of the pouring tube.

CONCLUSION

An apparatus which will produce atomized nickel powder has been constructed and a study has been made of the principles involved in the use of jets of air or inert gas to atomize metals.

An important factor in the successful operation of this apparatus was the heating of all the components in contact with the metal during pouring to the temperature of the molten metal.

This apparatus is not limited to the production of atomized nickel powder but could be used, with modifications, to atomize other metals.

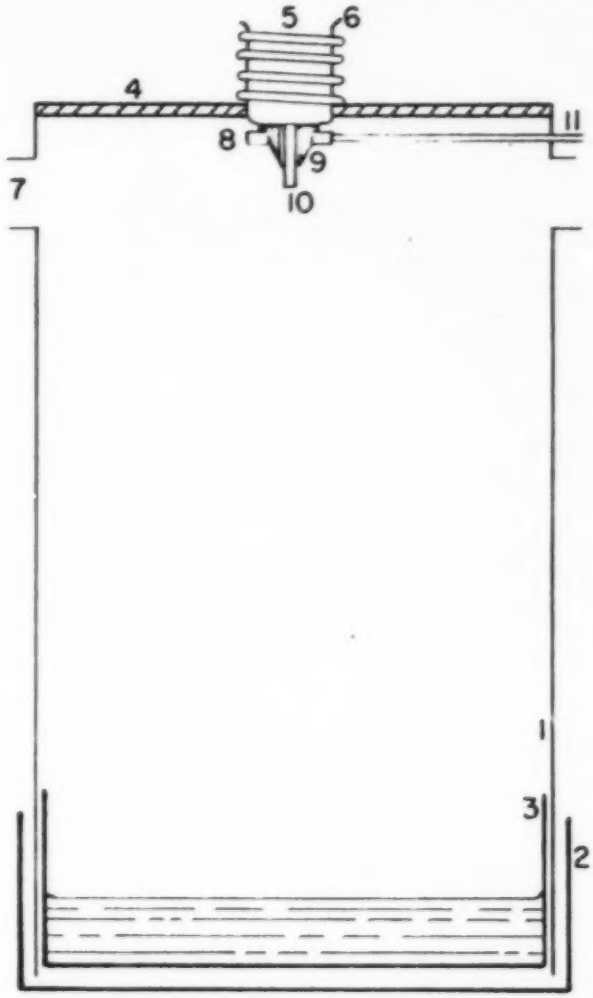

FIG.I ATOMIZING APPARATUS

1. Atomizing Chamber	7. Air Vents
2,3. Pans	8. Jets
4. Transite	9. Ceramic Shield
5. Heating Coil	10. Pouring Tube
6. Crucible	11. Air Supply

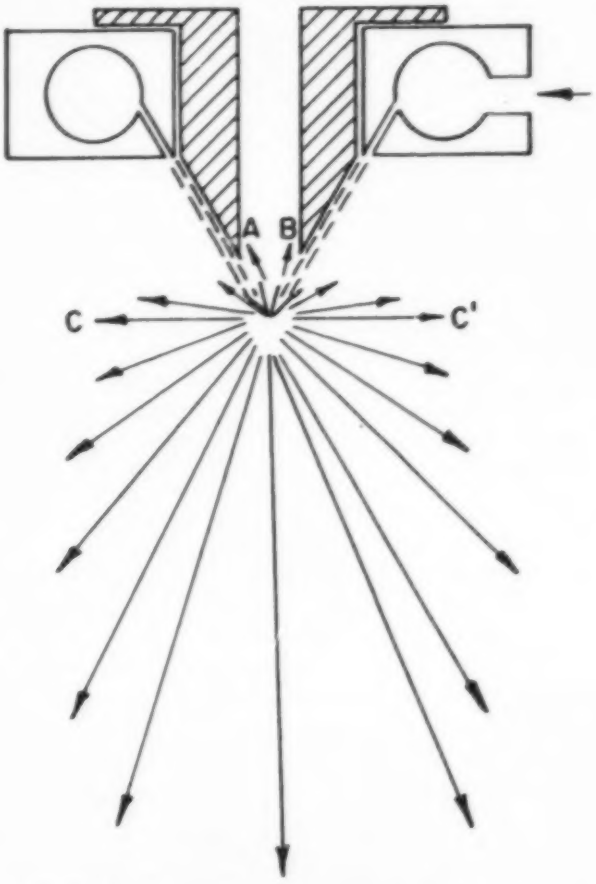

FIG. 2 JETS, CERAMIC SHIELD
PRESSURE AND DIRECTION OF AIR

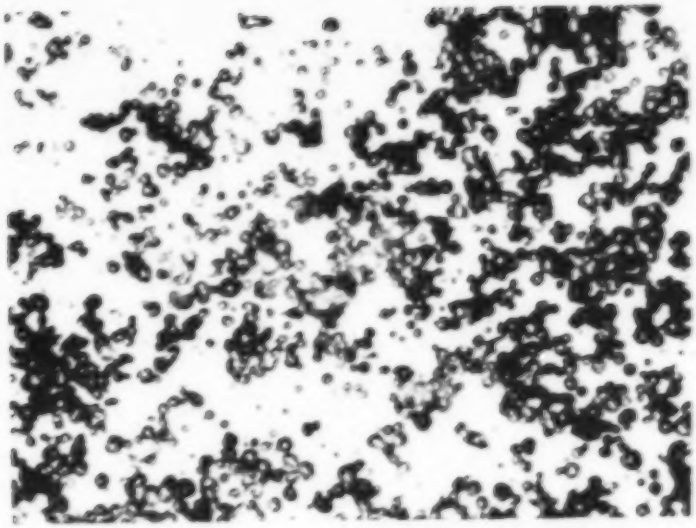

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Figure 3 - Ni Powder -325 Mesh